"Let not a single drop of rain water be allowed to reach the sea without benefiting mankind" – myth or reality ?

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Water, the most essential feature of nature at all levels determines how the natural world works. It abundance limits the distribution of plants and animals. The movement of materials in water is vital for both terrestrial and aquatic systems. Climatic patterns on a global scale to a larger extent are determined by the movement of water and the shape of the landscape determines the pattern of surface runoff. Water circulation through the hydrosphere is driven by gravity, solar and wind energies and depressions in the ocean atmosphere. Human activities may affect the global water cycle and thus, local availability of water. Deforestation, agriculture practices, alteration of wetlands and the re-routing or damming of streams and rivers are some of the activities that may affect the water cycle. Greenhouse gases, which increase temperature regimes, may also alter the global water cycle.

Monsoons determine the annual and seasonal distribution of water on the landmass of South and southeast Asia including Sri Lanka. The shape of the landscape and wind which determine the distribution of rainfall divide the landmass into distinct climate zones of less beneficial and more advantageous for the living being. People tampered with the hydrologic network since pre-historic time for irrigation and dry land farming which has resulted in changes in human civilization. Nevertheless, a progressive decrease in the quantity of water and deterioration of its quality on a global scale as a result of human intervention has now become a catchphrase. On the contrary, people still believe the famous saying of king Parakrama Bahu I (1153-1186 A.D), "let not a single drop of rain water be allowed to reach the sea without benefiting mankind". It is important to emphasize whether a country like ours can go further ahead with this ideology.

Freshwater

Sri Lanka, experiences two distinct monsoons, the southwest (May-Sep) and northeast (Dec-Feb). Primarily, monsoons bring rainfall, the only source of freshwater of the island. However, inter-monsoonal rains are influenced by atmospheric depressions that form in the Bay of Bengal and the Arabic Sea and the rainfall during the second inter-monsoon (Oct-Nov) is fairly widespread. The average annual rainfall is about 2000 mm. The intensity and distribution pattern of rainfall has divided the landmass into wet, dry and intermediate zones whereas the

south-central highland determines the drainage pattern. The streams and tributaries merge together downstream forming into rivers dividing the entire island into 103 drainage basins. Only the Mahaweli river discharges more than 10,000 million cubic meters annually into the Indian Ocean. Ten rivers are within the range of 1000-5000 million cubic meters and 63 rivers have less than 1 percent of Mahaweli discharge. The permanent standing water bodies are man-made in this country which is unfortunately not blessed with natural lakes.

Hydraulic civilization

Sri Lanka is reputed for her hydraulic civilization achieved through trans-basin diversions and construction of storage tanks since the pre-Christian era. Hydraulic civilization of ancient Ceylon has direct bearings with early human settlements in the dry zone. The diversion of Amban Ganga at Hattota Amuana and transfer of water through Elhera-Minneriya-Kantale Yoda Ela while creating Minneriya, Giritale, Kaudulla, and Kantale tanks is a classic example for partial diversion of major rivers to achieve inter-basin transfer. Transfer of water from Amban Ganga further downstream at Angammilldella creating Parakrama Samudra, the construction of Balaluwewa and Kalawewa, and inter-linking Kala Oya and Malwathu Oya through the 53 km long Jaya Ganga to convey water to Tissawewa, Nuwerawewa and Nachchaduwa on the Malwathu Oya basin reflect the mighty of irrigation wisdom of ancient Sri Lankans.

In addition, a large number of medium scale storage tanks, had been created in the north central dry zone either by arresting seasonal rivers or tributaries or by transferring water. Thousands of small shallow seasonal tanks of ancient category, which collect water only during rainy seasons from their own catchments and dry-off during the end of the dry seasons, were also in existence. Ancient water resource development in the southern dry zone was mainly confined to the Kirindi Oya and Menik Ganga basins although scholars argue that there are remnants of the ancient type in the Walawe River and Malala Oya basins. These schemes were mainly storage tanks of medium scale fed by diverted water without sophisticated link channel systems.

The ancient hydraulic civilization collapsed around the 12th century AD, and the reasons which led to the downfall remain unclear. However, attempts have been made to explain the collapse in relation to several factors such as foreign invasions and subsequent loss of water experts, decline of soil fertility, epidemics and famine. Apparently the ingenuity of water engineering of the ancient Ceylonese had gradually disappeared with shifting monarchies from dry zone to wet zone. Portuguese and Dutch (1505-1795), constructed canal network for flood protection and navigation confined to urban areas in Colombo

and western and northwestern coasts. Today, most of them have deteriorated and been converted into stagnant waterways. Hydrological changes resulting from the construction of the Old Dutch canal gradually transformed Muthurajawela a once very fertile rice field into marshes.

Since independence in 1948 we have accomplished several major hydropower and multi-purpose schemes by damming and diversion of upland rivers and creating new reservoirs and also augmenting existing ones. Major developments in the Kelani River resulted in Castlereigh and Maussakelle hydro-dams. Senanayaka Samudra, the largest surface water body in Sri Lanka(7,760 ha) was created in 1951 by damming the Gal Oya at Inginiyagala. Chandrikawewa and Udawalawe reservoir were built on the Walawe river during 1963-1968. The upstream of the Walawe river was arrested by a hydro-dam creating the controversial Samanalawewa in 1992. Construction of Lunugamvehera reservoir on the Kirindi Oya, upstream of the existing ancient reservoirs was completed in 1986 to transfer water via Badagiriya tank for downstream irrigation. The most recent surface water development in Sri Lanka was the completion of Mau Ara reservoir in the southern province in 2003.

Mahaweli

The government of Sri Lanka embarked on the multipurpose Mahaweli Development Programme (MDP) in 1970 on the recommendations made by the UNDP/FAO to provide irrigation facilities to 365,000 ha and hydroelectric power generation with an installed capacity of 507 MW. This project was recommended for stepwise implementation over a period of thirty years. In the first phase, a regulatory-weir (barrage) constructed at Polgolla transferred Mahaweli water to Kala Oya and Yan Oya while augmenting several existing tanks. Excess water of the Kalawewa-Balaluwewa twin reservoirs is conveyed through Jaya Ganga augmenting major tanks in the Anuradhapura district.

In 1980, the government accelerated the second phase of the MDP and completed it within a period of six years. This includes four major hydro-dams (Kotmale, Victoria, Randenigala and Rantembe) and Mahaweli and Maduru Oya interlink with Ulhitiya-Rathkinda and Maduru Oya reservoirs. The newly built water bodies inundated an area of about 15,000 ha, changing the hydrological network of the Central Mahaweli Valley and the Dry Zone Plain. The natural course of the Mahaweli River is still in existence although it empties water not only into the Koddiyar bay and Verugal coast but also into the Dutch bay in the Puttalam lagoon via the Kala Oya and to Vendaloosan bay via the Maduru Oya. Therefore, its flow regime, channel morphology, discharge

volume and sediment transport may certainly have been changed now as a result of changes that have taken place since ancient time.

Water balance

About 40 % of water received in the country through rainfall is discharged into the Indian Ocean. To day, it has decreased by about 17 % since water is stored in tanks and reservoirs. About 4 % of the reservoir water is lost through evaporation and the excess water of which is used for flood irrigation either seep down to the ground water table or flow downstream as irrigation drainage. Storage of running water in tanks and reservoirs has resulted in every 1 sq. km of land having 1.76 ha of water, which is an extremely high value of land to inland water ratio. The amount of water used for industries and domestic purposes are not that significant compared to the amount of water used for irrigation and hydroelectric power generation. Today, these man-made water bodies with their canals and channel systems have formed into a sophisticated hydrological network in the country.

Benefits

The developments in downstream irrigation since ancient time to date have resulted in a tremendous increase in rice production. At present, the country is self-sufficient in rice production and the historians claim that Sri Lanka has exported rice to neighboring countries during ancient time. Hydropower generation accounted for 12 % of the nation's energy requirement with a total installed capacity of 1441 MW. Since the country is not benefited with other natural energy resources such as coal or petroleum, tapping hydropower is inevitable. To date, Sri Lanka has tapped most of its potential hydropower resource to maximum level.

Beside these, reservoirs contribute as a potential biological resource by raising an important fishery. Inland fishery in Sri Lanka was a rural domestic activity limited only to catching of fish by traditional methods. At present these reservoirs yield about 20,000 metric tons per year amounting to 10-12 % of the national fish production. In addition to the food fish, 80,000 metric tons of trash fish can be exploited from these reservoirs. A majority of major irrigation reservoirs located adjacent to the townships in the dry zone provide drinking water for the people living in the vicinity. NWSDB abstracts water from Parakrama Samudra, Minneriya, Tissawewa, Nuwerawewa, Kantale, Udawalawe and Chandrikawewa for domestic water supply. People living in the vicinity also use reservoir water for washing and bathing although there is very little formal recreation use, such as boating, swimming and sport fishing.

Impacts

Alterations in the hydrological network at this magnitude would certainly result in environmental consequences. Impacts of watershed manipulation, trans-basin diversion and creation of large surface water bodies may be inevitable on a local scale rather than a global scale due to the relatively small size of the island. The volume of river discharges and subsequent material loading into the Indian Ocean via Sri Lankan rivers is insignificant compared to the Ganges, Bhramaputhra, Irrawaddy, Mekong etc. However, rivers enrich the estuaries and near-shore waters by carrying essential nutrients and sediments for sustaining coastal food webs and formation of beaches respectively. The Koddiyar bay and the Verugal coast where the Mahaweli River discharges has productive fishing grounds. Fish populations could be decreased or changed as it happened in the Nile estuary in Egypt following the completion of the Aswan dam. Such decline or changes have never been reported or else not been observed to date. Perhaps the amount of reduction in river discharge was not sufficient enough to change the coastal processes. Further, it has been predicted that dramatic environmental changes will occur in the flood plains of the downstream of the Mahaweli river.

On the contrary, significant environmental as well as socio-economic changes have occurred in Kalmatiya, Lunama, Kahanda Modara, Malala-Embilikala lagoons following the Walawe and Kirindi Oya Schemes. The failure of these new irrigation schemes especially in Kirindi Oya basin with the construction of Lunugamvehera reservoir has been attributed to erroneous hydraulic engineering design which has deviated from the ancient hydraulic ingenuity. The Malala-Embilikala twin lagoon system has been converted almost into a freshwater system changing the entire aquatic bio-diversity. On the other hand, salinity of the Kala Oya estuary near Dutch bay of the Puttalam lagoon has decreased significantly changing and depleting some brackish water species following the inter linking of Mahaweli and Kala Oya.

Sedimentation

Reservoirs constructed on the trunk stream of rivers are traps for nutrients and sediments. The reduced nitrogen and phosphorus could be compensated by the addition of fertilizer rich drainage water in the downstream although sedimentation of reservoirs cannot be avoided. By 1997, Kotmale reservoir had 7 % reduction from its original capacity whereas the capacity of the Polgolla reservoir has reduced by about 47% of its original capacity in 1976. Victoria reservoir has been saved by the Polgolla reservoir acting as sediment trap. The worst situation occurs in Rantembe, because of high soil erosion of the Uma Oya catchment.

Water quality problems associated with algal blooms have been reported only from a few reservoirs to date including Kotmale and Parakrama Samudra. Some species of bloom forming algae can produce chemicals that are toxic to mammals including humans. Dense algae blooms may cause serious problems on operational activities of hydro-dams and water treatment plants. Although there are a few incidents reported, mass mortality of fish in theses reservoirs have not been observed on a regular basis. The reasons for sudden out breaks of algal blooms and fish kills are hitherto unknown.

Biodiversity

Impacts of stream flow regulation on downstream aquatic fauna and flora due to habitat alteration and loss are well known. In developed countries impact assessment and implementation of mitigation measures are strongly imposed with river development projects as a measure of conservation of aquatic biodiversity. These aspects in our country were either totally neglected or loosely treated until the recent past. Although at present, *ad hoc* EIAs are carried out, implementation of mitigation measures and impact monitoring have not been rigorously undertaken, in water resource development projects. We know virtually nothing about the aquatic flora and fauna affected by water resource development projects in the past and the present. Apparently, construction of dams and regulatory weirs across the main river during the Mahaweli development has resulted in marked decline of eels and other migratory fishes. Mountain Labeo, a rare endemic species restricted to specific riverine habitats and reported only from the Mahaweli river, has now almost disappeared.

Remarks

Water resource development and management in Sri Lanka since ancient time to date has benefited people in many ways fulfilling their basic requirements. However, in the process of evolution of water resources development through a watershed-based ecosystem approach, the basic concept of ancient systems has gradually disappeared. Water resource developments during the Dutch and British periods were not focused to achieve the basic requirements of the nation. Most of the development projects implemented since independence were very ambitious and undermined the basic principles and concepts inherited in ancient systems. However, it is not rational to compare the sustainability of the ancient systems against the modern schemes since the reasons for the collapse of ancient systems still remains obscure and the river basins had not been altered then to the extent to what we have done at present.

The negative impacts of water resources developments in a small island like Sri Lanka are largely confined to local setting. The existing negative impacts in the present context can be minimized by understanding the holistic approach of scientific-based resource management in the development process for the well being of the nation. The famous dictum of King Parakrama Bahu denotes enthusiasm and it also reflects as ingenious knowledge on irrigation. No doubt that a watershed-based ecosystem approach was embedded in the ancient practice in Sri Lanka.